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GASPEE POINT. A TYPE OF CUSPATE FORELAND

BY ROBERT M. BROWN.

THE object of this paper is to introduce more widely a kind of shore form which is perfectly well defined and frequent enough in occurrence to merit a general recognition. A cuspate foreland is a point of land, extending into a body of water and bounded by two concave beaches meeting in a cusp. For a type, Gaspee Point has been chosen.

Location and Description.—Gaspee Point is situated about six miles south of the city of Providence, R. I., and forms a portion of the west coast of Narragansett bay. Its name has an historical significance and dates back to the period of restlessness just prior to the break between the American colonies and England. In 1772, a vessel of the royal navy, named the *Gaspee,* was detailed to patrol Narragansett bay, to prevent any violation of the Navigation Acts. There was little regard among the merchants and ship-owners of Providence for this instrument of England's oppression, and it is not unlikely that the commander of the *Gaspee* stirred this feeling into activity by his slight respect for the colonies and his overzealous efforts to perform the mandate of the king. One day while in pursuit of a colonial vessel, the *Gaspee* grounded on the bar of sand which has since borne the name of the ill-fated craft. The story is told that a Rhode Island skipper so conducted the chase that the pursuer was decoyed on to the dangerous ground. The men of Providence

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led by a prominent merchant, boarded the stranded vessel by night, seized the crew, and left the *Gaspee* burning on the sands.

From the sand cliff which overlooks Narragansett bay from the west, Gaspee Point extends into the water a fourth of a mile. Two beaches, concave in outline, one trending southwest from the cusp, the second west, form its water boundary. In the triangular area between the beaches and the higher land is a marsh, covered with the characteristic grasses on which cattle find pasturage. The marsh is fed by the seepage from the sand plain of the mainland. A stratum of clay near high water level, underlying the plain, determines the depth to which the percolating water may go, and the exposure of this impervious stratum by the dissection of the cliff opens a way of escape. Thus the marsh contains fresh water except

FIG. 1. GASPEE POINT AT HIGH TIDE, LOOKING EAST FROM EDGE OF SAND PLAIN.

when an occasional storm drives the waters of the bay over the beaches or when the lack of moisture from the plain and quiet seas deprive it altogether of its swampy character. To the south of the point, the sand cliff extends a half to three quarters of a mile to where it is broken and in part destroyed by the action of the sea. The sand cliff is breached by numerous short, although comparatively wide, valleys, and the material from them is transported seawards by the wash of the heavy sea and by the water that oozes in considerable quantities, in seasons, from the surface of clay at the base of the sand plain. So far has the destruction of this cliff gone that the southern extremity is an island during high tide. To the north of the point the cliff is soon lost in an initial reëntrant of the bay.

The slope from the plain to the water is not precipitous, as in the southern end, and no destruction of the banks by waves is visible. It is a grassy slope even to the border of the bay.

Gaspee Point is a cuspate foreland in the second stage of development. The V-shaped bars such as were described by Gilbert* in

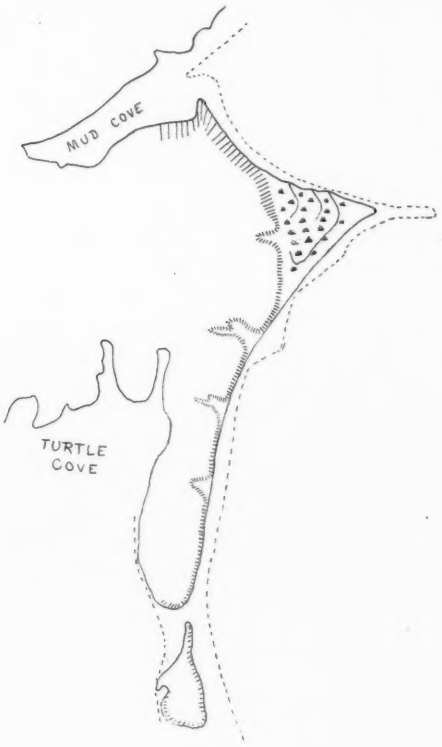

FIG. 2. MAP OF GASPEE POINT, ABOUT 5890 FEET TO THE INCH.

Lake Bonneville typify the earlier stage. Both beaches are not generally joined to the shore at this age and water is prevalent within the triangle. In the Gaspee Point stage the beaches are continuous and considerable filling has taken place in the lagoon area. Next

* "Lake Bonneville," Monog. I., U. S. G. S., 1890, 58.

comes the filled stage. Dungeness Point, on the south coast of England, is a foreland of this class.

Process of Formation.—Gaspee Point is not a final form. Work is still going on. From the processes now in operation some measure of the conditions of formation may be safely essayed. Observation shows: (1) That the sand bluff is to the south of the point. This bank, furthermore, is extensively ravined and the material from the cliff may be seen in transportation across the beach to the water's edge. (2) To the north of the point the glacial sand plain slopes more gradually to the shore of the bay. Its sides are grass-covered and no dissection of the bluff is visible. (3) From the enclosed lagoon in wet weather, a few small streams drain to the sea. No one of these enters the bay through the south facing beach. That beach is continuous and unbroken. One of the streams runs parallel to the south beach seeking a way of escape and finally empties into the bay, after crossing the point, through the north facing beach. (4) These streams running in a northerly direction, turn to the west before entering the bay. (5) Small deltas are formed at the mouths of the streams. (6) Narragansett bay is a tidal estuary. Its irregular contour gives good opportunity for eddying currents. Such currents have been proven about Gaspee Point. Bottles thrown into the water indicate the direction of the flow. Floats placed in the water by the City Engineers of Providence* in 1883, while investigating the removal of sewage yielded considerable evidence. That there is an outflowing current along the southern beach of Gaspee Point and an inflowing current along the northern beach, during a part of the day at least, is the result of these experiments. (7) The marsh is nearer the southern beach than the northern. (8) The sand is encroaching on the grass land to the north of the point.

Cuspate forelands are formed under the joint action of waves and currents. The waves buoy the material as they churn upon the shore and allow transportation by the currents. They also aid in transportation when they strike the shore obliquely. The current, in addition to the work of transportation, determines the shape of the foreland. Between adjacent eddies of a stream of water, there will be a triangle of comparatively still water. The base of this triangle will be the land. On the two sides of the area of still water the flow must be in different directions as opposite phases of eddies on the same side of a stream are contingent. When the sediment-bearing current reaches the edge of the dead triangle of water, its speed is

* Report of Engineers, City of Providence, 1884, Plate XX.

checked by the resistance offered by the stagnant conditions, deposition begins and a bar is formed along the inner edge of the outflowing current. As soon as the sediment reaches the apex of the triangle, the inflowing current is fed with sand and begins a similar bar formation along its leg of the triangle. The limit of such building is the water surface. With the aid of the winds and waves, the narrow tongues of land emerge from the water and the first stage of foreland development is completed. The landward end of the beach of the inflowing current will be the slowest in formation as it is the farthest point of building and in the Lake Bonneville types, the final joining had not been attained. The product of land

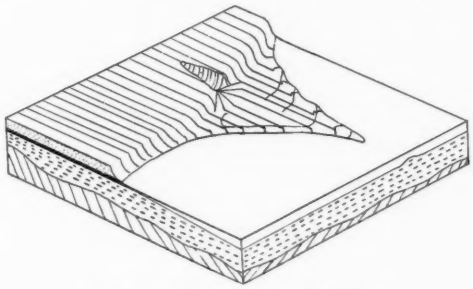

FIG. 3. DIAGRAM OF GASPEE POINT.

erosion and the material thrown over the beaches by the strong waves will in time convert the interior lagoon into a marsh. Soon the marsh will disappear and the foreland become a solid form. The points of fact, noted above, necessitate this manner of formation for Gaspee Point. The Report of the City Engineers of Providence yields almost conclusive evidence of current flow and current direction. Experiments with floats under different conditions and at different seasons reënforce this evidence. The story of the shores north and south of Gaspee Point is clear. The sand must have come from the southern bluff. This has been and is the great reservoir of supply. The absence of streams on the southern shore of the cuspate foreland indicates a stronger building power on that side. The stream which flows parallel to this beach cannot break through but must cross the point to the northern beach. The western deviation of the streams before emptying into the bay is best explained by the 'long-shore current. Such a feature is not rare and examples may be seen in those rivers of New York state, which turn

eastward before flowing into Lake Ontario, or the Garonne, which turns northward before emptying its waters into the Bay of Biscay. The small streams of the foreland assist the bay currents in transporting the sand. By their agency the sand may be *short-circuited* across the point instead of performing the more laborious journey around the apex of the triangle.

Waves and Currents.—There has been some contention as to the relative value of the forces of waves and currents in a form of this nature. In certain lakes as the Bras D'Or and Lake George, cuspate forelands are described* as wave-formed. The action of currents is not recognized as a potent factor. It is however impossible to separate the two forces. Gilbert† estimates the value of waves and currents in the following words:

"The agent of littoral transportation is the joint action of waves and currents. Usually, and especially when the wind blows, the water adjacent to the shore is stirred by a gentle current flowing parallel to the water margin. This carries along the particles of detritus agitated by the waves. The particles wholly or partially sustained by the water are at the same moment as being rolled to and fro carried in a direction parallel to the shore by the shore currents. The shore current is nearly always exceedingly gentle and has of itself no power to move detritus. When the play of the waves ceases all shore action is arrested. When the play of the waves is unaccompanied by a current, shore action is nearly arrested but not absolutely. * * * If there were no currents a great amount of transportation would undoubtedly be performed by waves striking obliquely but it would be carried on at a slow rate. The transporting effect of waves is so slight that only a gentle current in the opposite direction is necessary to counteract it. The concurrence of waves and currents is so general a phenomenon, and the ability of waves alone is so small, that the latter may be disregarded. The practical work of transportation is performed by the conjoint action of waves and shore currents."

In lakes where there is a show of wind waves and the current is slight, cusps are but weakly developed. In estuaries of strong tidal current as Narragansett bay there are many large and well developed forelands. Capes Hatteras, Lookout and Fear are cuspate forelands formed by the strong back-set eddies of the Gulf Stream. A study of a large number of cuspate forelands shows no proportionate

* Tarr, R. S., "Wave-formed Cuspate Forelands," *Amer Geol.*, 1898, 21, 1–12; Woodman, J. E., "Shore Development in the Bras D'Or Lakes," *Amer. Geol.*, 1899, 24, 329–42.

† Gilbert, G. K., "The Topographic Features of Lake Shores," Fifth Ann. Rep. U. S. G. S., 1883, 75.

uniformity of development under changing conditions of wave action and it seems safe to assert that the forms are not in any way proportional to wave value. On the other hand there seems to be an evident progression in the prominence of these forms as the strength of the current is increased. Furthermore, apart from any consideration of transportation, it is not easy to conceive of conditions, repeatedly recurring, under wave action as the prominent factor, that will yield the cuspate outline. It seems to be necessary to invoke the aid of currents to fashion the foreland and to account for its growth.

Evolution.—A history of the growth of cuspate forelands has been sketched. Two points concerning Gaspee Point remain to be considered. First, the fact that the marsh is nearer the southern than the northern beach and, second, the encroachment of the sand on the land to the north. There appears to be a growth northward. The case of Cape Canaveral or False Cape on the east coast of Florida indicates the manner of growth quite clearly. Here the advance is southward. The stages of growth are made apparent by the lines of sand ridges built by the action of the sea. The lines of a previous stage are being obliterated on the cutting side (northern) and new lines are appearing on the building side (southern). False Cape is now within the bar which forms the northern shore of Cape Canaveral and its growth as a foreland is ended. The lines of growth on Gaspee Point are parallel to the shore line and exhibit no such manifest movement. The process of cutting may or may not be active on the southern shore. However there is a building northward by the sand that rounds the point and the sediment borne by the streams that drain the marsh and this extension of the northern shore would leave the marsh nearer the southern. As the bars were the product of deposition by the eddying currents, the shore line is determined by that current. If the eddy remains fixed in position, no change in the shore is likely to occur. If, however, the eddy travels one way or the other, the foreland may be expected to follow it. The eddy cannot remain constant. The action of the waves and tides upon the shore and on the bay as a whole will cause a variation. Therefore we may expect our cuspate foreland to change. The final action of waves on a shore is to straighten it as may be seen on the eastern side of Cape Cod, the southern shores of Nantucket and Martha's Vineyard, the New Jersey beaches and many other examples of mature coast lines. Upon such shores cuspate forelands do not as a rule appear. Where currents exist the

limit of action is a shore line where the greatest degree of harmony obtains between waves and currents. Such a result may be illustrated by the Texan coast. In the case of the bay if the eddying currents are the result of irregular shores and the tendency of the waves is to subdue and straighten the irregularities, the final form in the cycle results when the waves fit the bay and reduce the eddies to a minimum if they do not entirely destroy them.

Catalogue of Cuspate Forelands.—That the cuspate foreland is not a product of any one locality but is a type of form which prevails on many coasts, the following incomplete catalogue will prove. For many of these the author is indebted to Gulliver.*

NORTH AMERICA: *East Coast.*

Gaspee Point, Narragansett Bay, Rhode Island.

Sandy Point, Block Island, Rhode Island. Position determined by a former island, now tied to the main land.

Sand Point, Narragansett Bay, Rhode Island. On the east side of Prudence Island; projected into deep water; smaller than average cusp; has no inner marsh.

Sachusett Point, Narragansett Bay, Rhode Island. A tied island; in lagoon stage.

The Bonnet, Narragansett Bay, Rhode Island. Appears to be a tied island; in lagoon stage.

Conimicut Point, Narragansett Bay, Rhode Island. A tied island.

Coatue Cusps, Nantucket, Massachusetts. Six promontories of sand in Coatue Bay, extending 200 yards or more. Show active building out towards deeper water. Three contain salt water ponds.

See Shaler, N. S., Bull. U. S. G. S. 53, 13.

Cape Hatteras, North Carolina. See C. Abbe, Jr., on Cuspate Capes of Carolina Coast. *Proc. Bos. Soc. Nat. His.*, 1895, 26, 489–497. Also Gulliver, Cuspate Forelands, *Bull. Geol. Soc. Amer.*, 1895, 7, 408.

Cape Lookout, North Carolina. See Hatteras.

Cape Fear, North Carolina. See Hatteras.

Cape Romain, South Carolina. See Hatteras.

Cape Canaveral, Florida. Gulliver, Shoreline Topography, *Proc. Amer. Acad. of A. and S.*, 1899, 34, 180.

Cape San Blas, Florida. Shows stages of growth. Filled stage.

* Gulliver, F. P., "Shoreline Topography," *Proc. Amer. Acad. of A. and S.*, 1899, 34, 214–220.

Point Jefferson, Louisiana. Second or Lagoon stage.
Uvita Point, Costa Riça. A tied island.

West Coast.

Sextant Point, San Quentin Bay, Lower California. Built out between two rocky headlands.
Point Discovery, Oregon. Encloses Lagoon.
Aro Island Cusp, Washington.
Point Monroe, Washington. A looped bar first stage.
New Dungeness, Puget Sound, Washington. Second stage. Named by English sailors after Dungeness Point, England, because of resemblance.
Walan Point, Port Townsend, Washington. Lagoon stage.
West Point, Washington. Filled stage.
Sand Point, Popof Strait, Alaska. A somewhat blunted point. Lagoon stage.
Douglas Island Cusp, near Juneau, Alaska. Filled stage. A low water cusp; high tide covers it.

Lakes.

Bonneville Cusps, Utah. Sites of these cusps are now represented by a V-shaped bar, enclosing a basin, a former lagoon. See Gilbert, U. S. G. S. Monog. I., 1890, 58.
Bras D'Or Cusps, Bras D'Or Lakes Cape Breton Island. Tarr, Wave-formed Cuspate Forelands, *Amer. Geol.*, 1898, 21, 1–12; Woodman, Shore Development in the Bras D'Or Lakes, *Amer. Geol.*, 1899, 24, 329–342.
Crowbar Point, Lake Cayuga, New York. See Tarr, *Amer. Geol.*, 1898, 21, 1–12.
Lake Lahonton Cusps, Nevada. Russell, Lake Lahontan, U. S. G. S. Monog. XI., 1886.

SOUTH AMERICA.

Dungeness Point, Straits of Magellan. Filled stage. Named by English sailors after Dungeness Point, England, because of resemblance.
Estangues Point, Venezuela. Filled stage.

EUROPE.

Dungeness Point, Romney Marsh, England. Filled stage, showing successive lines of growth. Gulliver, Dungeness Foreland, *Geog. Journ.*, 1897, 9, 1–11.

Jaederens Point, Norwegian Coast. A small filled cusp.
Schaaf Island, Holland. A filled cusp, built out in front of the dikes.
Wisner Bay Cusp, Germany. A rounded cusp, projecting into the Baltic.
Zingst Point, Germany. Built up of several islands tied together.
Dars Cape, Baltic Sea, Germany. Shows 38 successive shorelines by dune ridges.
Frische Haff Cusps, Germany. Similar to Coatue Cusps.
Kurische Haff Cusps, Germany. Similar to Coatue Cusps.
Horup Bay Cusps, Faaborg, Denmark. Lagoon stage.
Del Faro Point, Sicily, Italy. Between currents of straits of Messina and large eddy of Tyrrhenian Sea; shows progressive series of additions.
Alice Point, Italy. Filled stage. Projected into the Gulf of Taranto.
Baliton Lake Cusp, Austria. Opposite a volcanic island in the lake. The island probably determines the position of currents.

PHILIPPINE ISLANDS.

Cuba Point, Cuba Island. A filled cusp.

POSTGLACIAL ORIGIN AND MIGRATIONS OF THE LIFE OF THE NORTH-EASTERN UNITED STATES

II

BY CHARLES C. ADAMS.

A comparison of the three waves brings out some interesting relations and contrasts, similar to those which one might observe in travelling south from the barren grounds of Canada through the stunted tree growth near the tree limit, on through the belt of dark, coniferous forests into the deciduous forest belt of Illinois. The types of plant and animal life thus observed would be fairly representative of the forms which have passed successively over parts of the northern United States since the Glacial Period. These waves

of dispersal were widespread, but perhaps only the first was of universal occurrence over the region under consideration. Only the first wave reached the high alpine summits of the White Mountains, while the first and second reached the Appalachian mountains, the lowlands alone being reached by all three. The first wave must have been composed of but few species, though abundant in individuals, but the second had a greater variety of species; and in the third the proportion of species was greatly increased, while at the same time there was a corresponding decrease in the number of individuals of the same kind.

The present distribution elsewhere of the types represented by the three waves is instructive. The types of the first are distinctly of circumpolar distribution; that is, their continuous distribution is in the polar regions. In the case of the second there is also a circumpolar distribution of many of the forms, but there are certain forms limited to restricted areas; while in the case of the third wave we have forms which show still more restricted distribution, and correspondingly a less number of forms of wide distribution. It is in this third wave that we find the *characteristic American* forms of life. Thus with each successive wave there was an increase in the diversity and number of forms peculiarly American, which, pushed into or over the northeast. The first and second waves are thus at present considered characteristically *northern,* and evidently originated under boreal conditions. The affinities of the third wave clearly point to the *south* for its postglacial origin, although in this wave there is an important element in both its flora and its fauna which suggests a preglacial northern origin.

We may look to the south in two directions for the geographic origin of the third wave. *First,* to the region directly south, or the southeast, with its genial climate, abundant rainfall, deciduous forests, and abundance and variety of animal life both on land and in the streams; and *second,* to the west and southwest, with its arid climate and prairie or desert types of life. Each made its contribution to the third wave, but in very different proportions. The southeastern United States had the advantage of proximity and a climate similar to that of the region to be invaded, and shows to a corresponding degree its greater influence upon the life of the northeast. From what has already been said of the history of the northeastern United States it is very evident that the present life of that region is in a sense an overflow from the south. This is most emphatically true of the third wave, which shows plainly its southern affinities. In studies of

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geographic origin it is thought fairly safe to consider the region in which a group of animals or plants reaches a maximum development, as the centre of dispersal. This is certainly a safe criterion in the case under consideration.

Several groups of plants and animals occur in abundance in the southeastern states, and with numerous varieties which occur elsewhere only in limited numbers. This can be illustrated by the river mussels. The greatest development of river mussels in the world occurs within a radius of three hundred miles of Chattanooga; and more species occur within this area than in all the remainder of the world. The southeast is therefore well recognized as a centre of distribution of these shells. The river mussels of the Mississippi drainage in the northeast plainly show by their affinities that they have been derived from this region and that they are an overflow from the southeast.

When the principles used in determining geographic origin are applied to the study of the life of the northeast, some very interesting relationships at once become apparent, which point clearly and distinctly to the southeast for the origin of several characteristic groups of plants and animals. Only a few of the more prominent and dominant types can be mentioned, and of these the famous rich deciduous forests must first be noted. There is no finer development of deciduous trees in the world than in eastern North America; and botanists clearly recognize that the forests of the northeast are of undoubted southeastern origin. This same origin holds almost equally well for the herbaceous vegetation, excepting the western prairie forms. Among animals, the land snails show the same condition of affairs. They are very abundant in the southeast and have spread to the northeast. This also holds true for both the crayfish and river snails. Among vertebrates the tree-toads, salamanders, and turtles all belong to this same general category in showing a southeastern origin, and it will not be surprising if the same should prove to be true in the case of fishes, birds, and mammals.

While the southeast has undoubtedly been the most important centre of dispersal for the third wave types, it has not been the only one. The smaller element from the west and southwest must be given its due, though small, credit. This western influence, as might be anticipated, is most conspicuous in the more prairie sections of Iowa, Minnesota, Wisconsin, and Illinois. These prairies have furnished a favorable home for a number of plants and animals whose relationship and origin assuredly point to the west and south-

west. The distribution of pocket-gophers and ground-squirrels indicate such an origin. Many typical forms of the Great Plains are evidently of southwestern origin, the Plains having been their outlet or highway from the far southwest. The Plains as a highway of dispersal have previously been noted. It is instructive to determine the geographical origin of the elements into which the life of a region may be reduced upon analysis. Our investigations should not stop at this stage, but should include, if possible, a study of the conditions which determine the presence of these different elements and the pathway along which they must have travelled in order to reach their present destination.

From the Great Plains east there is a prairie highway reaching as far east as northern Indiana, and forming a sort of peninsula extending east from the Great Plains into a densely forested region. This peninsular highway is composed of parts of northern Iowa and Illinois, and of southern Minnesota and Wisconsin. While the general direction of the prairie peninsula is toward the east, in reality it functions as a southwestern highway, because many of the types of the Great Plains are of distinctly southwestern origin. This is a highway for land forms only, because it does not coincide with any drainage system; in fact, it runs counter to those occurring within its limits.

Leading to the north from the southeast, there are two very important highways. *First*, and most important, is the Mississippi river and valley, and tributaries. This great avenue of dispersal has furnished abundant opportunities for the dissemination of a great variety of forms. Fertile valleys are especially favorable for the northward extension of southern types of plants and animals, in striking contrast to the conditions under which some northern forms flourish in southern regions, as in the case of the "boreal islands." These islands, whether they are on alpine mountain peaks, stagnant swamps, or arid sand-dunes, all stand for severe conditions; and it is very remarkable that there is so much similarity in types found under extreme conditions of whatever kind, a similarity which has given rise to a vast amount of confusion in the study of the causes of distribution. But fertile valleys favor northward dispersal of certain types only, while others attain a more northward distribution in arid, sterile regions, as in the case of the Great Plains. That the Mississippi river and tributary streams and valleys have been a great avenue for aquatic and amphibious life is so evident as to be hardly worthy of mention. The *second* important outlet is from the

southeast, and this has been along the Coastal Plain. This pine barren Coastal Belt has favored, as did the Great Plains, a northward extension of a southern association of types.

From the preceding facts and relations, which have been hastily reviewed, it should be apparent that in the past history of a region, the conditions and highways must be taken into consideration if we wish to understand the origin and migrations of the diverse elements which enter into the fauna and flora of any given region.

The biological landscape of the northeastern United States has passed through wonderful transformations since the glacial ice covered the region. Let us by way of summary briefly picture, as best we can from our knowledge of the conditions, the general succession of life which followed northward the final retreat of the ice.

Let us imagine ourselves standing upon some vantage ground (say the forested region of southern Wisconsin), and watching the succession of forms slowly and gradually pass northward close to the base of the retreating ice. A zone of bare ground fringes the edge of the glacier, where the fluctuations of the ice and the glacial torrents subject the soil to frequent disturbances. Farther away on stable ground variegated mosses and lichens flourish in abundance, while in the shallow bog-like depressions, between the knolls of the drift, sedges and rushes grow in great profusion. The same plants fringe the borders of ponds, lakes, and sluggish streams, whose noisy water-birds announce that summer migrants have again returned. Brilliantly colored arctic plants, gentians, saxifrages, and anemones, grow in solid banks and cover protected slopes. In the sheltered valleys and along the banks of the larger streams, stunted willows and birches make shelter for the ptarmigan, while all else is a vast treeless waste.

The first wave of life has passed on, and though there is no break or sudden change in the procession, there is a constant and marked transformation continually taking place. By degrees the mosses and lichens no longer give tone to the landscape; grassy meadows and stunted willows, birches, and alders speed further and further from the banks of the streams. Later, trees of larger size, pines, hemlock, spruce, and larch, multiply in number, and the barren aspect of a treeless waste has gradually passed away as these pioneers of the second wave move forward; and with it a dense forest of conifers crowds upon the grassy meadows, and breaks them up into islands surrounded by a sea of evergreens. The landscape now presents a dark and dense forest of evergreens, through whose branches the

wind soughs and moans, and whose forest floor is carpeted by a dense, damp mat of mosses and pine needles. These mighty forests hold such absolute sway that it seems as though nothing could dislodge them; but the pioneers of the third wave now begin to creep to the north and insinuate themselves, as a wedge, along the fertile valleys. These flat-leaved deciduous trees appear to make but little advance with each advance of the procession, it becomes more evident that the third wave is slowly moving on with its oaks, hickories, ashes, maples, and walnuts, and a host of shrubs and herbaceous plants with their varied animal associates, those types which characterize the northeast to-day. Along the prairie peninsula there comes a small delegation from the Great Plains, and up the Mississippi valley a vast assemblage from the southeast, making up the great bulk of the fauna and flora of northern United States, that show southern affinities.

CANYONS OF SOUTHEASTERN COLORADO

BY WILLIS T. LEE, TRINIDAD, COLO.

MUCH has been written of the canyons of Colorado and many photographs published illustrative of their beauty and sublimity, as well as of their geographic features. But in the public mind the canyons of Colorado are located either in the mountains or in the plateau region west of the mountains. Few people seem to know that canyons of any notable depth exist east of the mountains in what is commonly known as the Great Plains. But there are canyons in the Great Plains many miles in length and hundreds of feet in depth. While they are not so extensive as some of the better known canyons of the plateau region west of the mountains, they are of no mean proportions and their grandeur and beauty well repay the effort necessary in gaining access to them.

These canyons are found east of the mountains in the southern part of Colorado and the northern part of New Mexico, and extend eastward in the case, at least, of the Rio Cimarron, somewhat beyond the eastern boundary of New Mexico. The two principal canyons of northern New Mexico are the Rio Cimarron and the Canadian.

There are two Cimarron rivers in New Mexico. The one referred to here is near the northern border of the territory and flows eastward through Oklahoma and Kansas to the Arkansas river. The principal canyon of southeastern Colorado is the Purgatory. There are several smaller ones such as the Huerfano and the Apishapa but I shall confine myself in the present paper mainly to the Purgatory and its branch canyons.

The general elevation of the Great Plains is well known. Along their western border, the elevation is about a mile above sea level. Over the greater part of the plains region the elevation is too slight

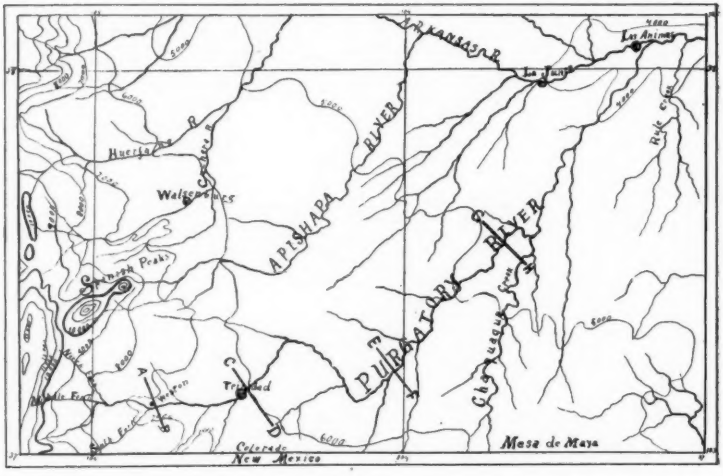


FIG. 1. MAP OF A PART OF SOUTHERN COLORADO SHOWING THE REGION IN WHICH THE PURGATORY, APISHAPA, AND HUERFANO RIVERS HAVE CUT CANYONS. (Contours taken from U. S. G. S. topographic sheets.)

to allow of canyon cutting. But in southeastern Colorado and northeastern New Mexico there is an extensive uplift which has raised the surface far above the general level of the plains. This uplift has been referred to by R. T. Hill in his Physical Geography of the Texas Region * as a series of benches which he calls the Mesa de Maya and the Las Vegas plains. The surfaces of these plains and mesas lie from 6,000 to 10,000 feet above sea level, and include the canyons under consideration. I shall for the present confine

* U. S. Geol. Surv. Topographic Atlas, Physical Geography of the Texas Region, p. 8.

my attention to those found north of the crest of this uplift, leaving those in the southern slope for later consideration.

The forms of the canyons vary according to the rock formations penetrated by them and for this reason it will be necessary to sketch briefly the simpler facts of the geological conditions. The trunk streams rise in the crystalline area of the Sangre de Cristo Mountains and cut through the upturned formations in geological order from the Carboniferous to the Tertiary. Owing to the rock structure the rivers on entering the plains region cut these formations in reverse order from the Tertiary rocks to the Red Beds, which are of Jura Trias age. Considering the formations concerned in order from top downward—the Tertiary beds are found only on the highlands and do not properly enter into the compositions of the canyon walls. The Laramie is composed of sandstones and shales of varying hardness in which valleys of greatly varying form are cut. Underneath the Laramie lies the Fox Hills sandstone, a resistant layer which forms prominent canyon walls and escarpments. This is underlain by the soft Pierre shales, 1,200 to 1,300 feet thick, and the limestones and shales of the Niobrara and Benton formations, 600 to 700 feet thick. The next formation, the Dakota sandstone, 300 feet thick, here as elsewhere, is exceedingly resistant and usually forms precipitous walls wherever dissected by the streams. Beneath this sandstone lie the soft Morrison shales (Atlantosaurus beds) 200 to 300 feet thick, which in turn are underlain by the Red Beds. The upper series of the Red Beds, 175 to 200 feet in thickness is massive and resistant and forms rugged canyon sides.

For convenience in the description of the Purgatory river and its canyons, I shall divide its course into four divisions: (1) The head waters or mountain division extending from the sources of the various branches to the place where these branches enter the plateau region near the town of Stonewall. (2) The division included in the high plateau east of the mountains and extending from Stonewall to Trinidad, a distance of about 40 miles. (3) The broad open plain between Trinidad and the point 25 miles east of Trinidad where the river cuts through the Dakota sandstone. (4) The canyon proper extending from 25 miles east of Trinidad nearly to the Arkansas River, a distance of something like 70 miles, taking no account of the windings of the river. It is this last division which presents the greatest interest not only on account of the great variety of topographic forms and the beauty of form and color, but also because here is found a typical canyon.

XUM

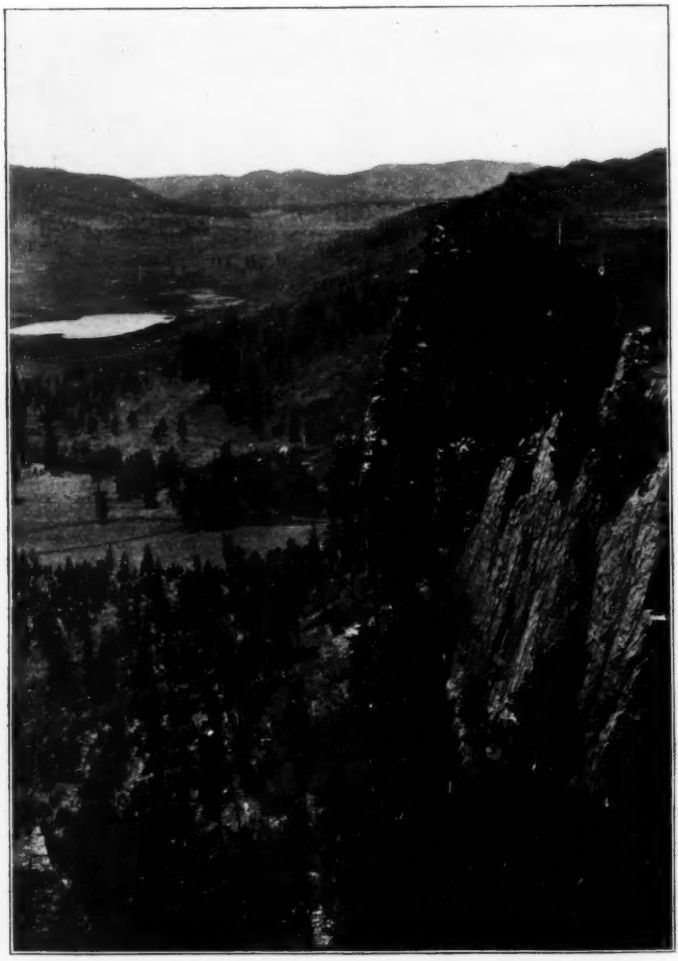


FIG. 2. THE "STONEWALL," SHOWING THE RIDGE FORMED BY THE UPTURNED DAKOTA SANDSTONE WHICH APPEARS ON THE SERRATE CREST. The "Park" at the left is formed by the erosion of the Cretaceous shales, that at the right of the wall by the erosion of the Morrison shales. (Photograph by Walter Dearden.)

1. There are three main branches of the Purgatory, the South Fork, the Middle Fork and the North Fork. These unite shortly after leaving the foot hills proper. The canyons in which these streams flow are in no way remarkable. They are deep narrow V-shaped valleys such as are to be found throughout the mountain region.

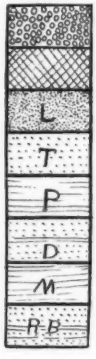
Perhaps the most unusual and noteworthy feature in this part of the river's course is what is locally known as the "stone wall." The sedimentary formations are so strongly upturned along the foothills that they stand nearly vertical. The Dakota sandstone resting as it does, in its upturned condition, between the soft Morrison shales

FIG. 3. THE "STONEWALL" NEAR THE TOWN OF STONEWALL, COLORADO.

on the one hand and the soft shales of Colorado and Montana age on the other has been left in the process of erosion as a prominent wall. The Morrison shales west of the wall—stratigraphically below—have been worn away leaving a more or less continuous depression. The equally soft shales to the east have also been deeply eroded and long "parks" formed parallel to the wall. The result is that a ridge whose crest is the serrate edge of the Dakota sandstone extends along the mountain front for a distance of about forty miles. In other localities the Dakota sandstone is not so nearly vertical and

is known as the Dakota "hog-back." Along the crest of the ridge in the region under consideration the Dakota rises as a sheer wall to a height in places of several hundred feet. Figure 3 is a photograph of the "stone wall" taken near the town of Stonewall where the Middle Fork of the Purgatory emerges from the foothills.

2. The second division of the river's course is perhaps less interesting than the first division. The canyon is a V-shaped valley whose sides are more or less rugged according as the layers of the Laramie formation through which it cuts happens to be hard or soft. In general the valley sides are not so rugged but that they are clothed with vegetation. This part of the course, about forty miles in length, lies within the dissected plateau situated east of the mountains. The streams have penetrated the Tertiary sands and gravels (leaving remnants of them on the hill tops north of the river) and the extrusive sheets of basalt which still cap the mesas to the south and east; they have penetrated the Laramie which is 800 to 2,500 feet thick and have cut, in the vicinity of Trinidad, 550 feet below the base of the Laramie. In this distance of forty miles there is a fall of about 2,050 feet making an average gradient of 51 feet to the mile.



POISON CANYON FORMATION (EOCENE?)
BASALT.
LARAMIE FORMATION.
TRINIDAD SANDSTONE (FOX HILLS).
PIERRE SHALE.
DAKOTA SANDSTONE.
MORRISON SHALE.
RED BEDS.

FIG. 4.

It may be of interest in this connection to know that the coal lands dissected by the Purgatory and its branch streams in this plateau region are probably the richest in Colorado. Coal is extensively mined in this region and many new mines are opening at the present time. The coal lands capped by the Tertiary formation north of the river and by the extrusive sheets of basalt south of the river form the high plateau extending eastward from the mountains.

Near the town of Sopris, a few miles west of Trinidad, the river descends into a narrow canyon the walls of which are maintained by the hard stratum of Fox Hills sandstone. The walls at Trinidad rise 550 feet above the river bed. The lower 400 feet of the walls are made up of Pierre shale. The highlands to the northwest are capped with Tertiary sands and gravels and those to the south and east with extrusive sheets of basalt. The basalt cap and possibly the Tertiary as well, mark the original surface, so far as known, upon which the present streams began to work. The surface of the basalt sheet is 3,636 feet above the river bed at Trinidad. This figure may be taken as a measure of the downward cutting which the Purgatory has accomplished at this point.

3. The third division extending from Trinidad eastward for twenty-five miles is in no sense a canyon. At Trinidad the river

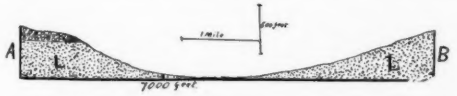


FIG. 5. CROSS SECTION OF PURGATORY VALLEY AT WESTON.

emerges from the hills of the dissected plateau upon a broad undulating plain. At this point the Fox Hills sandstone turns north, away from the river's course and makes a prominent escarpment for many miles. This escarpment forms the eastern edge of the dissected plateau previously referred to. From the foot of the escarpment eastward, the surface is occupied in turn by Pierre shales, the Niobrara and Benton limestones and shales, and the Dakota sand-

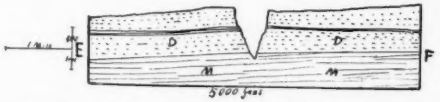


FIG. 6. CROSS SECTION OF A PART OF THE PLAINS 30 MILES EAST OF TRINIDAD, A FEW MILES BELOW THE POINT WHERE THE PURGATORY PLUNGES INTO ITS CANYON.

stone. A wide area has here been degraded to the condition of a rolling plain. The amount of degradation can be estimated from the height of the mesas south of the Purgatory which stand at a maximum elevation of 3,636 feet above the river bed and which are, as previously stated, probably parts of the original surface upon which the present Purgatory River began to flow. From this max-

imum elevation which obtains in Fisher's Peak, the mesa surfaces decline to the east diminishing somewhat the elevation above the river bed. It should be noted in this connection that Fisher's Peak is not a *peak* in any sense of the word. It is a projecting point of the high mesa and not a summit rising from the mesa surface as has been stated in some published accounts of this region. It has the appearance of a peak from the vicinity of Trinidad because the observer gazes up at the projecting angle which is the point of the mesa nearest to him. This rise of 3,636 feet within a horizontal distance

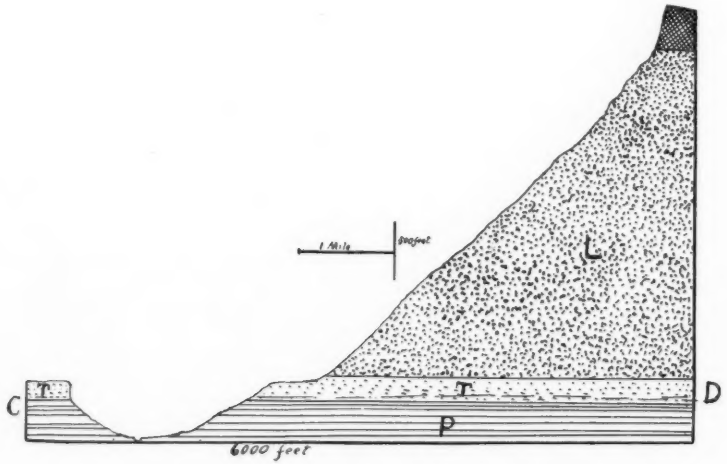


FIG. 7. CROSS SECTION OF PURGATORY VALLEY AT TRINIDAD, FROM FISHER'S PEAK TO SIMPSON'S REST (FOX HILLS ESCARPMENT). The basalt at the top is the cap rock of Raton Mesa.

of five miles gives this projecting angle the appearance of being a peak rising from the general surface of the mesa. An excellent photograph of this "peak" has been published by Mr. Hill in his geological folio of this region.* Figure 8 is a near view of the "peak" showing the character of the protecting cap. The photograph is illustrative of the "palisades" fringing the mesas on all sides. The sides of the "peak" are nearly vertical but this is not shown in the illustration since the photograph was taken looking upward.

* U. S. Geol. Surv. Geological Atlas, Elmoro Folio.

The mesas south of the river extend eastward at least 80 miles. Beyond this I cannot speak from personal observation. There are many more or less isolated mesas, the more important of which are Johnson's Mesa, Raton Mesa and Mesa de Maya. These were formerly connected as one great table land to which Mr. Hill has applied the name Mesa de Maya from the easternmost of these great mesas. This name is peculiarly appropriate as it means "the table of mail" or "the armored mesa." The mesas or table lands are capped with basalt having a maximum thickness of about 500 feet. The basalt is

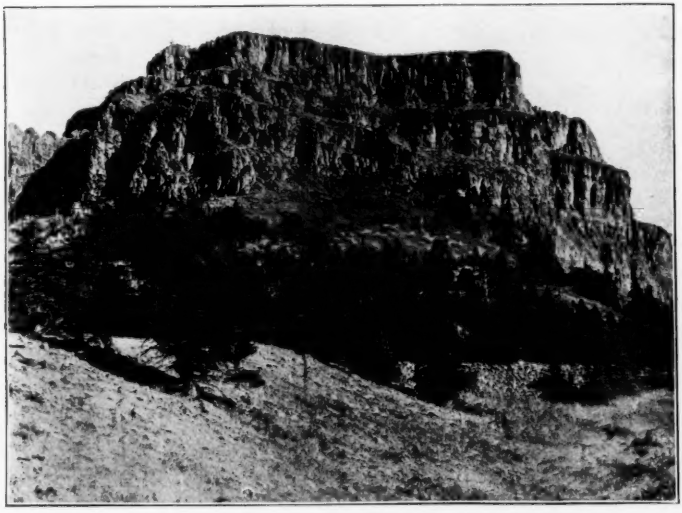


FIG. 8. FISHER'S PEAK, TAKEN FROM A POINT NEAR THE FOOT OF THE "PALISADES." The columnar basalt at this point is about 500 feet thick.

more or less columnar and forms palisades bordering the mesas. From the palisades on the north the surface descends rapidly at first but gradually becomes less precipitous until it finally merges into the undulating plain over which the river now winds.

This descent of a maximum of 3,636 feet within a distance of five to fifteen miles gives opportunity for the formation of many swift side streams. These streams have developed long, sloping débris-covered mesas similar to those which I have described elsewhere from Boulder, Colorado.* Their débris caps are composed largely of

* The Origin of the Débris-covered Boulder, Colorado, *Jour. Geol.*, Sept.–Oct., 1900.

basaltic material from the tops of the mesas, although in many places crysalline débris from the mountain brought down by the river appears commingled with the fragments of basalt. These débris-covered mesas may be seen in typical development a few miles southeast of Trinidad.*

4. In the last or fourth division of its course, the Purgatory enters the most picturesque and interesting, as well as the most inaccessible and unknown part of its course. About twenty-five miles east of Trinidad it cuts through the Dakota sandstone and gradually works its way downward through the Morrison shales and deep into the Red Beds, making a canyon seventy miles long, measured in a straight line, and 900 feet in maximum depth. Throughout the length of this region the Dakota sandstone is the rim rock. The rolling plain described in the third division is evidently a plain of

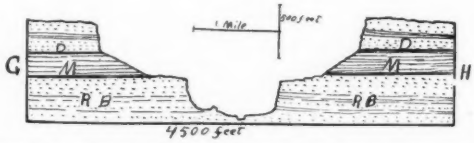


FIG. 9. CROSS SECTION OF THE PURGATORY CANYON WEST OF ITS JUNCTION WITH CHAQUAQUA CANYON. The cliffs of the Dakota and the Red Beds, the even slope of the Morrison shales, and the bench at the top of the Red Beds are found here in typical development.

degradation. In passing from the western border of this plain eastward, one passes in succession over the Pierre, Niobrara, Benton and Dakota formations. But the surface in the region of the canyon proper is, with minor exceptions, a broad stratum plain controlled by the Dakota sandstone. The two merge into one general plain similar to that south of Mesa de Maya which Mr. Hill calls the Las Vegas Plateau. It differs, however, from the Las Vegas Plateau in that it is not bordered by escarpments as is the case south of Mesa de Maya. On the contrary the general surface of the country in the vicinity of the canyon proper follows the Dakota sandstone which dips to the north and east. The surface therefore descends by a gradual slope to the valley of the Arkansas River.

The Dakota is massive and resistant and forms persistent cliffs 100 to 300 feet high wherever dissected by the streams. From the base of these cliffs the canyon sides descend in comparatively gentle

* See map. U. S. Geol. Surv., Geological Atlas, Elmoro Folio.

slopes for a vertical distance of 200 to 300 feet over the Morrison shales. The regularity of the slope is often interrupted by the Dakota débris, but in general the slope is governed by the shales and is somewhat uniform. At the base of this slope occurs an extended bench formed by the upper series of the Red Beds. The bench varies from a few feet to several miles in width and is often perfectly denuded exposing the bare rock for long distances. From this bench to the bottom of the canyon the walls are made up of the red sandstones and shales of the Red Beds. The controlling layer

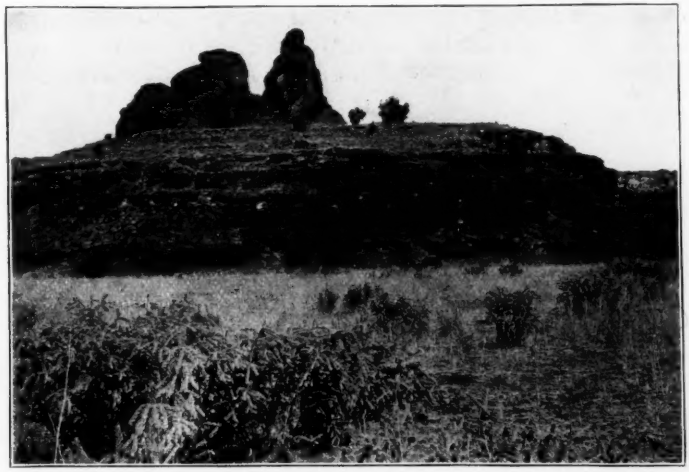


FIG. 10. A MESA BUTTE OF RED SANDSTONE, CHAQUAQUA CANYON. The foreground is a stratum bench sparsely covered with bush cactus. The size of the cliff may be estimated from the horse and wagon at its base.

of this series lies near the top. It is a massive coarse sandstone 175 to 200 feet thick. Below this massive layer the walls are made up of thinner sandstone layers alternating with red shales. It is in this red sandstone series that the wonderful beauty of form and color resides, which makes the canyon memorable to those who have once seen it. The region is locally known as the "Red Rocks Country."

The width of the canyon varies greatly according to locality. The upper third is a little more than a mile in width with a maximum depth of about 400 feet. Below this it widens and deepens to its maximum dimensions. Where Chaquaqua Creek enters the Pur-

gatory, the canyon floor is 900 feet below the surface of the rim rock. This descent is accomplished within a horizontal distance of a little less than two miles. In some places the canyon broadens until it is several miles in width, while in others it narrows until the floor is little wider than the river bed.* This deeply dissected portion extends for a distance of about 40 miles, then gradually passes to a less deeply dissected region and finally merges into the comparatively open plain.

The increased dimensions of the canyon both in depth and width in the region of its junction with Chaquaqua Canyon is probably due in some measure at least to a local uplift. The general surface of the plain at the head of the canyon is about 5,500 feet above sea level. Seventy miles farther down the river the surface lies approxi-

FIG. 11. THE JUNCTION OF THE PURGATORY AND RED ROCKS CANYONS, taken from a stratum bench shown in the foreground. In the left background the precipitous edge of the rim rock (Dakota) appears. Beneath the Dakota occurs the envelope of the Morrison shales. The middleground with the cliff at the right shows the Red Beds with a broad bench at the top. The canyon at this point is 400 feet deep.

mately 4,000 feet above sea level. If the surface, which in general is formed by the Dakota sandstone, had a uniform dip it should lie at an elevation of about 4,750 feet near the mouth of Chaquaqua Canyon. It lies, instead, at an elevation of about 5,300 feet, 550 feet higher than a uniform dip would place it. From the head of the canyon, therefore, to the mouth of Chaquaqua Creek, a distance of thirty-five miles, the rim rock lies practically horizontal. In the lower thirty-five miles of the canyon the surface elevation is lowered about 1,300 feet.

Where the canyon is cut in the Red Beds the various hard layers of sandstone form more or less distinct benches. The floor of the

* See U. S. Geol. Surv. Topographic Map, Timpas Sheet.

canyon is, in many places, a succession of benches one above another like huge steps. In the wider portions of the canyon these benches appear either as broad shelves along the canyon sides or as low, flat topped mesas rising from the canyon floor.

Some of the side canyons in the region where the Purgatory is deepest are scarcely less noteworthy than the main canyon. Some are extended and varied like Chaquaqua Canyon. Others are short and steep like Red Rocks Canyon, Iron Canyon and a score of others. Chaquaqua is the largest of the branch canyons and is about thirty miles long. Its scenery is no less grand and beautiful than that of the main canyon.

FIG. 12. APISHAPA CANYON.

The river is comparatively swift in the canyon and is still corroding its bed. In the 70 miles of the canyon, measured in a straight line, the river flows at least 80 miles, perhaps more, and descends 1,600 feet. Assuming that 80 miles expresses the actual length of the river the average gradient is about 20 feet to the mile. Some of the short side canyons have a much higher gradient. Iron Canyon for example descends 400 feet in about three miles or about 133 feet per mile.

The Purgatory is called a river. But the eastern reader must not think of it as comparable to the rivers which he is familiar with in the East. At ordinary times the water of the river if gathered together would make a stream something like five feet wide and a foot deep at the average rate of flow. Some of the branch canyons have no permanent streams. Chaquaqua Creek has excavated a canyon about thirty miles long with a maximum depth of 900 feet, and yet there is so little water in the stream during the dry months that the bed of the creek is used as a wagon road. In our trip up the canyon we drove for about ten miles in the bed of the stream and were nowhere inconvenienced by the water. But during the spring and early summer especially when the snows are melting from the mountains, the river swells to somewhat notable proportions, and it is subject also to sudden torrents during the summer months. The highlands of the plateau region east of the mountains which are drained by the Purgatory are subject to frequent sharp showers sometimes called "cloud bursts" which make sudden and destructive floods. It is to these floods that we must look for an explanation of the great abrasive power evidenced in the formation of the Purgatory canyon.

In the Apishapa canyon * we have a beautiful illustration of a young canyon. The Apishapa River is smaller than the Purgatory and flows parallel with it. The canyon is cut in the region where the uplift—perhaps better defined as a large monocline—previously described, extends across the course of the river. The canyon is about fifteen miles long with a maximum depth of something over 300 feet. The canyon walls are exceedingly precipitous and made up almost wholly of Dakota sandstone. The stream flows in a deep narrow gorge to which side canyons have not developed to any notable extent. The "river" flows only part of the year. The name, Apishapa, is an Indian word meaning *stinking water,* so called from the stagnant pools formed along its course during the dry months when there is no permanent stream. The force of the stream is spent in cutting downward. The canyon from rim to rim is one fourth of a mile to one mile wide and the floor is little wider than the stream during times of flood.

* See U. S. Geol. Surv. Topographic Map, Apishapa Sheet.

DECISIONS OF THE U. S. BOARD ON GEOGRAPHIC NAMES, FROM JANUARY TO JUNE, 1902

Aektok; island, near west end of Avatanak island, Krenitzin group, eastern Aleutians, Alaska. (Not Aiaktak, Goloi, Goly, Ouektock, nor Rootok.)

Agamgik; bay, indenting the northern shore of Beaver Bay, Unalaska island, eastern Aleutians, Alaska. (Not Food.)

Barnett; run, near Bridgeport, Harrison County, West Virginia. (Not Barnet.)

Battery; point, the eastern head of Sarana bay on south shore of Akutan island, eastern Aleutians, Alaska. (Not Kainak, Liberty Cap nor South Head.)

Bentons Ferry; Post Office and Railroad Station, Marion County, West Virginia. (Not Benton Ferry.)

Bonaire; island, one of the Dutch West India Islands, in the Caribbean Sea, off the coast of Venezuela. (Not Buen Ayre.)

Bosporus; strait between Black Sea and Sea of Marmora, Europe. Note: This is a reversal of the decision Bosphorus rendered by the Board, January 12, 1897.

Chiwawa; creek, Chehalis County, Washington. (Not Chiwahwah.)

Cobun; creek, in Monongahela County, West Virginia. (Not Coburns.)

Connorville; Post Office and Railroad Station, Jefferson County, Ohio. (Not Connor nor Connorsville.)

Curlew; creek, lake and Post Office, Ferry County, Washington. (Not Karamin nor Karamip.)

Davisson; run, branch of Simpson creek, Harrison County, West Virginia. (Not Davidson's.)

Davisson; run, branch of West Fork river, Harrison County, West Virginia. (Not Davidson's.)

Fassett; point, Sinepuxent bay, Worcester County, Maryland. (Not Fassetts nor Henry.)

Forest; lake, in Woodbury, Orange County, Maryland. (Not Slaughters Pond.)

Fudges; creek and Post Office, Cabell County, West Virginia. (Not Fudger.)

Gibson City; Post Office and Railroad station, Ford County, Illinois. (Not Gibson.)

Glenns; run, Ohio County, West Virginia. (Not Glenn's.)

Glenns Run; Railroad Station, Ohio County, West Virginia. (Not Glen's Run.)

Goosmus; creek, Ferry County, Washington. (Not Goos nor Koosmus.)

Green Village; Post Office and Railroad Station, Franklin County, Pennsylvania. (Not Greenvillage.)

Horrell; precinct, Frontier County, Nebraska. (Not Howell.)

Howes; cave, in Cobleskipp, Schoharie County, New York. (Not Otsgaragee.)

Howes Cave; Post Office, Schoharie County, New York. (Not Howecave, Howe Cave, Hows Cave, nor Howe's Cave.)

Hupa; Indian tribe, mountain and Post Office, Humboldt County, California. (Not Hoopa, Hoopah, Ho-pah, Hupâ, Hupô, Noh-tin-eah, nor Uppa.)

Hupa Valley; Indian agency and reservation, Humboldt County, California. (Not Hoopa Valley.)

Iliuliuk; the chief town of Unalaska, eastern Aleutians, Alaska. (Not Unalaska.)

Inner Manchas; coral reef or bank on north side of entrance to Mayaguez bay, Porto Rico, West Indies. (Not Inner Machos, etc.)

Jaffrey; point, the southern point of entrance to Portsmouth Harbor, New Hampshire. (Not Jaffray nor Jerry's.)

Kenneatto; creek, Fulton and Saratoga Counties, New York. (Not Fonda nor Kennyetto, etc.)

Kisselen; bay at the head of Beaver bay, Unalaska, eastern Aleutians, Alaska. (Not Kissialiak, Warsham nor Worsham.)

Lehi; Post Office and Railroad Station, Utah County, Utah. (Not Lehi City.)

Levashef; port or harbor at head of Unalaska bay, Unalaska, eastern Aleutians, Alaska. (Not Captains nor St. Paul.)

Machos Grandes; coral reef or bank, on south side of entrance to Mayaguez bay, Porto Rico, West Indies. (Not Alart, Great Manchas, not Machos.)

Manchas; coral reef or bank, on north side of entrance to Mayaguez bay, Porto Rico, West Indies. (Not Machos Grandes.)

Manchas Chicas; coral reef or bank, on north side of entrance to Mayaguez bay, Porto Rico, West Indies. (Not Machos Chicos.)

Marcy; mountain peak, the highest point in the Adirondacks, Essex County, New York. (Not Tahawus.)

Mechanicville; Post Office and village, Saratoga County, New York. (Not Mechaniesville.)

Note: this is a reversal of the decision Mechaniesville rendered by the Board, April 4, 1900.

Outer Manchas; coral reef or bank, on northern side of entrance to Mayaguez bay, Porto Rico, West Indies. (Not Outer Machos.)

Pereleshin; mountain, east of the Stikine river and near the Alaska-Canada boundary line. (Not Pereleshini.)

Provo; Post Office and Railroad Station, Utah County, Utah. (Not Provo City.)

Rabbit; creek, Ferry County, Washington. (Not St. Helen.)

Raquette; lake, Hamilton County, New York. (Not Racket.)

Raquette Lake; Post Office and Railroad Station, Hamilton County, New York. (Not Racket Lake.)

Raquette; pond, Franklin County, New York. (Not Racket.)

Raquette; river of northern New York, draining lake and pond of same name, and emptying into the St. Lawrence River. (Not Racket.)

Samganuda; bay, indenting the eastern shore of Unalaska, eastern Aleutians, Alaska. (Not English.)

St. Helens; mountain in Skamania County, Washington. (Not St. Helen.)

St. Peter; creek and flat, Ferry County, Washington. (Not Rock.)

St. Vrain; creek and precinct, Weld County, Colorado. (Not St. Vrains.)

Sanpoil; lake and river, Ferry County, Washington. (Not Rowena nor San Poil.)

Sea Gull; six rocky islets between Unalga and Akutan, in Akutan pass, eastern Aleutians, Alaska. (Not Baby or Gull.)

Sigak; cape, the north point of Akutan Island, eastern Aleutians, Alaska. (Not North Head.)

Southmayd; Post Office and Railroad Station, Grayson County, Texas. (Not Southmayde.)

Steel; mountain in the Olympic group, Jefferson County, Washington. (Not Steele nor Stone.)

Tangik; islet near the eastern shore of Akun Island, Krenitzin group, eastern Aleutians, Alaska. (Not Waverly.)

Tanginak; islet, east of Akun Island, in Unimak pass, Alaska. (Not Breed nor Propagation.)

Tanaskan; bay indenting the southern shore of Beaver bay, Unalaska, eastern Aleutians, Alaska. (Not Macks nor Taneska.)

Toroda; creek and mountain, in Ferry and Okanogan counties, Washington. (Not Tarrota nor Toroda.)

Ugalgan; island, near the easternmost point of Unalaska, eastern Aleutians, Alaska. (Not Egg, Galgin, Iachnoi, Jaitschoi, Kigalgin nor Orieshik.)

Unalaska; bay indenting the northeastern shore of Unalaska island, eastern Aleutians, Alaska. (Not Captains.)

Urilla; bay, on the northern coast of Unimak, eastern Aleutians, Alaska. (Not Shag nor Shaw.)

Usof; bay, indenting the southeastern shore of Unalaska, eastern Aleutians, Alaska. (Not Whalebone.)

Valdes; glacier, narrows, port, summit and town, Prince William Sound, Alaska. (Not Valdez.)

Van Etten; Post Office, Railroad Station, township and village, Chemung County, New York. (Not Vanetten.)

Wallkill; river, in Ulster and Orange counties, New York. (Not Wall Kill.)

West Fork; river in Marion, Harrison and Lewis counties, West Virginia. (Not West Fork Monongahela.)

Wheeling; creek, Ohio and Marshall counties, West Virginia. (Not Big Wheeling.)

Wheeling; island in Ohio River at Wheeling, West Virginia. (Not Madison nor Zanes.)

Willow Island; Railroad Station, Dawson County Nebraska. (Not Willow.)

Witchcoat; point, Back River, Baltimore County, Maryland. (Not Witchcoate.)

THE MISSISSIPPI RIVER

THE Mississippi River, extending over a length of 2,550 miles, has been placed by the United States Government under the charge of a commission, whose duties include the making of a detailed survey of the channel from the headwaters to the Gulf of Mexico; a topographical survey showing the natural and artificial features lying within a mile of the river; a system of tri-

angulation with base lines along the stream; longitudinal and cross sections of the channels; observations and records as to floods; and, for the assistance of future surveys, the placing, at intervals of three miles, of permanent marks, consisting of four stone or vitrified tile monuments in a line normal to the stream, two on each bank, about half a mile apart. The commission has also the charge of the works carried out for regulating and deepening the channel.

Mr. J. A. Ockerson, who is a member of this commission, and who, in the year 1899, made a survey of the headwaters of the Mississippi, contributed a paper on the subject to the *Proceedings* of the International Congress on Navigation held at Paris last year,* from which the principal part of the information here given has been obtained.

The Mississippi is one of the largest rivers in the world. It penetrates the heart of the most fertile portion of the United States for a distance of 2,550 miles, and has 15,000 miles of navigable tributaries. Its headwaters rise amidst the pine-clad hills of northern Minnesota, where the long winters reach almost a polar cold, and winds its way through the varying conditions of climate of ten great states to the semi-tropical lowlands of southern Louisiana, finally losing itself in the Gulf of Mexico. Its drainage area, of over one and one fourth million square miles, covers nearly half of the United States, and is equal to the whole of Europe exclusive of Russia. The region which it drains has no equal in any part of the world for fertility of soil and natural resources, such as vegetable products, timber, coal and minerals of various kinds. On its surface are borne immense cargoes of grain, coal and lumber gathered from the resources of a vast district and despatched across seas to all parts of the world. In its upper reaches it affords power to innumerable saw mills and flour mills, and manufacturing industries.

The source of this great river has long been the subject of controversy. The earliest white explorers who first visited the country where the Mississippi rises were the French fur traders, but the earliest authentic account of the exploration of its source is that of William Morrison, who visited the district in 1804. The next explorer who recorded the results of his survey was R. H. Schoolcraft, in 1832, who located the headwaters in Lake Itasca. In 1872 the

* "The Mississippi River: Some of its Physical Characteristics and Measures Employed for the Regulation and Control of the Stream." By J. A. Ockerson, member of the U. S. Mississippi Commission, Eight International Congress on Navigation. Recorded in English and French. Paris, 1900.

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New York Herald sent a representative to visit the source of the river, with instructions to navigate the stream thence to the Gulf of Mexico. Again, in 1879, the *Louisville Courier-Journal* sent an expedition to Itasca Lake. It was not, however, until 1889 that the first thorough exploration of the basin was made under the direction of the Minnesota Historical Society.

The State of Minnesota has set aside a reservation of 35 square miles, covering the basin of Lake Itasca, thus preserving forever sacred the source of the father of rivers in the "Itasca State Park."

Unlike the origin of most large rivers which commence as mountain torrents, the Mississippi leaves its source with a width of 30 feet and a depth of 5 feet, and starts on its journey at an altitude of 1,560 feet above sea level. Commercial navigation reaches to within 25 miles of the lake, and thousands of sawn logs are floated down the stream every summer. At about 60 miles from the source the Government has constructed reservoirs, capable of holding 93,746 million cubic feet of water, for the purpose of regulating the supply of water to the channel and maintaining a navigable depth in summer. Near St. Anthony, about 500 miles from the source, are rapids which have been made use of for obtaining water power for working saw and flour mills and other manufacturing industries. Steamboat navigation commences near the junction of the Minnesota River, where the river has fallen 870 feet, 548 miles from the source.

A little above the junction with the Ohio, about 1,400 miles down, the water becomes heavily charged with sediment, and the country is subject to flooding. The extreme range between high and low water at St. Louis is 37 feet. The slope of the water there falls six inches in a mile. Sand bars are numerous, and although the discharge amounts to 35,000 cubic feet a second in dry seasons there is not frequently more than four feet over the bars. Works are being carried out along this length for regulating the width of the channel and dredging away the bars so as to secure a better navigable depth. Where the banks are subject to excessive erosion they are protected by mattresses of woven willows, and the banks graded by hydraulic action. Along this reach the river is exceedingly crooked. Between Arkansas and Greenville the distance along the river is 40 miles, the air line being only 15 miles. It also has great width, the banks, which are from 30 to 40 feet high, being in places two miles apart. The maintenance of these "levees" or banks is of

vital importance to the surrounding country, as a breach would result in the inundation of 50,000 square miles of rich alluvial land.

One of the greatest difficulties which the management and the navigation has to contend with is the immense amount of drift-wood carried down in floods. This wood, if not cleared away, gets caught in the bends and accumulates, forming with the alluvial matter an effective barrier to the flow of water and a source of danger to the banks. For the removal of this drift-wood special vessels, called snag-boats, are employed, which patrol the river and remove the snags.

Dredgers of large type, and provided with very powerful machinery, are in constant employment for removing sand bars and shoals. The type now almost universally in use for this purpose is worked by centrifugal pumps, which raise the sand and in some cases deliver it over the banks. Where the material is hard, cutters are provided at the end of the suction pipes of the pumps, which loosen the clay or hard material sufficiently to allow of its being sucked into the pipes. One of the most recent of these machines is capable of raising more than 4,000 cubic yards of material an hour, and is fitted with electric light, machine shops, and all appliances necessary to repair the machinery and keep it in going order.

For the lower part of its course the river winds its way through a vast delta, twisting and turning by numerous bends until it extends its length to nearly double the point to point length of the delta. This delta is 500 miles long, and from 30 to 40 miles in width, covering an area of 400,000 square miles. It is composed of material transported by the current and deposited in the estuary, which at one time extended from the original outfall to the Gulf of Mexico. The river is still pouring solid matter into the Gulf, where it is spread out in a fan-like shape over a coast line of 150 miles and is filling it up at the rate of 362 million tons a year. Some idea of the vastness of the silent operations of nature may be conceived when the fact is considered that this solid matter consists of the wearing away of the land through which the river flows, and that some of it must have been transported a distance of over 3,000 miles; and that if the whole of it has to be carried in boats for half the total distance at the lowest rate at which heavy material is carried on the inland waterways of America, or, say for one tenth of a penny per ton per mile, the annual cost of transport would amount to no less a sum than 238 millions of pounds.

The channel in the lower reach is narrow, not exceeding half a mile in width, the depth in places exceeding 200 feet, and everywhere sufficient to float large sea-going craft as far as the junction of the Red River, a distance of more than 300 miles.

On this length is situated the city of New Orleans, 110 miles above the Gulf of Mexico. Ships of all nations reach this port. Its wharves extend over fifteen miles of river front, and are crowded with vessels of every description. Grain and cotton form the chief item of export.

As the river approaches the Gulf it is split up into three principal channels. The smaller of these has been improved by restraining walls made of mattresses and stone which extend over the bar out into the deep water of the Gulf for more than two miles. This work was undertaken by Captain Eads, under contract with the Government to provide, for a certain sum of money, a depth of twenty-six feet at low water, and to keep and maintain this depth for a period which has now expired.

The description of this mighty river above given will surely warrant its being called the "Father of Waters."—*Nature*, March 28, 1901.

GEOGRAPHY CURRENT

CARTOGRAPHY

Topographic Maps of New York.— The U. S. Geological Survey has recently issued a number of topographic map sheets covering portions of New York State, which was surveyed by the Federal Bureau in coöperation with the state of New York; they are as follows: The Auburn quadrangle, which covers a territory in the vicinity of the city of Auburn, showing parts of Owasco and Cayuga Lakes; the Sodus Bay quadrangle, showing a part of the Lake Ontario shore eastward some thirteen miles from Sodus Bay; the Moravia quadrangle, showing portions of Cayuga, Tomkins and Cortlandt Counties, including the towns of Moravia and Groton; and the Tarrytown quadrangle, showing the Hudson river from Dobbs Ferry to Stony Point, including Tarrytown, Nyack, Ossining, Haverstraw and the surrounding country. The aqueduct system for the supply of New York City is indicated, as is also the location of the new dam on Croton Lake. Each of these sheets covers a rectangular section

13 x 17½ miles, showing the usual features of settlement, highways and drainage. They also reveal the inequalities of relief by the use of contour lines passing through points of equal elevation, which show the shapes and slopes of the hills and mountains. They may be had at five cents each on application to the Director of the U. S. Geological Survey.

PHYSIOGRAPHY OF THE LANDS

An Interesting Boulder Wall in Sanilac County, Michigan.*—The "wall" occurs in the swamp and was originally covered to a slight depth by vegetable mould. By the burning of the mould in the process of clearing the swamp a few years ago, the wall was exposed. It lies adjacent to the west margin of the swamp and parallel with it. Its distance from the margin is about 150 yards. The embankment has been exposed for a distance of half a mile or more, and beyond this it has been traced for a considerable distance through the marsh by a line of stones which probably marks its site. In places the "wall" is low or absent entirely. The width of the embankment at the base is about eight to ten feet, and it rounds to a broad apex. It is composed chiefly of glacial boulders of various sizes embedded in a stiff blue clay. In places the interstitial material is a sandy marl supposed by those who regard the "wall" as the work of prehistoric man to be of the same character as the marl underlying the rest of the swamp. Immediately under the embankment the sand is packed quite hard for a depth of two or three inches as shown by excavation. The height of the "wall" is usually about 18 inches to two feet, though in places somewhat higher. A marked feature of the embankment is the presence of large stones scattered along the surface, while the lower portion is made up almost entirely of smaller stones. Some of the stones at the top are two or three feet in diameter. A similar but less distinct embankment was observed adjacent to the east side of the marsh. It is said that like occurrences have been noted at various points in Greenleaf and Austin townships, but no effort was made to verify the report.

Various theories to account for the presence of these embankments abound locally, most of which ascribe them to human agencies. The prevailing belief seems to be that they represent a forti-

* Abstracted by permission from Geological Report on Sanilac County, Mich., by C. H. Gordon, and published in Vol. VII, Part III, of Reports of Geological Survey of Michigan.

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fication. Another theory is that they are the remnants of a former breakwater or levee. From a study of the physiographical and structural features of the region, however, it is evident that the "wall" is due to natural agencies.

At one time the region was a long narrow lake or bay possibly connected with a larger body of water toward the southeast. Further evidence of the former existence of a lake here is found in the marl deposits underneath the vegetable mould. The ice forming over this shallow lake would enclose the boulders resting on the bottom, and by its expansion would thrust them shoreward. So also floating ice under the influence of a strong wind has been known to drive boulders of considerable size upon a bank several feet in height and some distance back from the edge of the water. Professor T. C. Chamberlain, commenting on this as a probable explanation, says that this action is much more likely to affect large boulders than small ones, and, besides, the fine material is washed out to a greater or less extent, so that the coarse, heavy boulders appear on the surface while finer material lodges in the mass under their protection. From the configuration of the surface it is evident that the lake must have been shallow at the time these embankments were formed, so that in winter the water was frozen to the bottom for a considerable distance from the shore, if not over the whole lake. Whatever was on the bottom, therefore, would be enclosed in the ice and thrust shoreward by its expansive force.

The Walled Lakes of Iowa, which have received considerable notoriety from the popular belief that the embankments on their borders were the work of aboriginal inhabitants, have been shown by White* to be due to ice thrust. He says: "It is true that the motion resulting from one winter's freezing would hardly be perceptible, but the act repeated from year to year, and century to century, would ultimately move everything upon the bottom beyond the reach of the ice. The tracks of the boulders thus moved have been observed, being as unmistakable in their character as those which the river mussel leaves behind it in the sand." * * * "Below the line of freezing the material would of course remain unmoved upon the bottom because there is nothing to disturb it."

"The real embankments are only found separating a piece of low land from the lake, because the material thrust out by the ice against the steeper banks merely accumulates there upon the slope

* "Geology of Iowa," 1870, Vol. I, p. 74.

which rises above any such accumulation, and, also, of course above the high water line of the lake. In such cases the shore is thickly studded with boulders thrust against it, but the material meeting no such obstruction on a marshy side accumulates in circular ridges around the lake, and these are the walls which have excited so much wonder."

The observations hitherto recorded apply solely to walls around the borders of lakes.* In the present instance the lake has long since disappeared, and its site has become covered to a considerable depth by vegetable mould.

CLIMATOLOGY

The Acclimatization of the Peach.—One of the recent discoveries in pomological science shows a rather curious phase of the adaptation of plants to their environment. Many plants take advantage of the fact that dark colors absorb heat, and in unfavorable localities they assume reddish, rather than greenish tints so that they may absorb heat and live. This is particularly noticeable in Alpine plants, many species having a reddish variety for high altitudes and a variety of lighter color for warmer locations. The oak buds in spring and the dying leaves in autumn are reddish; some roses have a pink color in the early blossoms, are white in midsummer, and again red in autumn. Many plants can assume the warmer color if occasion demands, as was shown in the Leipzig botanic garden this spring. The exceptionally cold weather of May caused some species to put forth leaves so red as to make the specimen almost unrecognizable. The workings of this law are not without their economic aspects.

Professor Whitten, of the University of Missouri, has discovered† that the American peach crop suffers from the fact that the trees of many varieties have purple twigs, absorb too much heat in the winter sunshine, bloom too early and perish from frost. The varieties of peaches cultivated in America are the descendants of those that have come from France and England, where, having struggled for centuries against a cool climate, they have developed reddish

* Boulder walls similarly formed are common features of the lakes of the northern United States. Tyrrell, formerly of the Canadian Geological Survey, has reported and illustrated such walls at Lake Winnepegosis, where the shoreward movement of boulders has been 32 feet in a single season. A large boulder in a New Hampshire lake was moved 18 feet in one winter, and other instances might be given. An excellent boulder wall may be found on the west side of Chautauqua Lake, N. Y., in the grounds of the Chautauqua Assembly.—R. E. D.

† Bulletin No. 38. Experiment Station of the Missouri State University.

twigs and have only prospered when spread out flat against a sunny wall. The selection of early ripening specimens for propagation has hastened the reddening process which becomes a disadvantage in the warmer climate of America. The following table shows the effect of color on twig temperatures:

Temperatures on a Sunny Day in Winter (Centigrade.)				
Atmosphere.	Whitened Twig.	Natural Green Twig.	Natural Purple Twig.	Blackened Twig.
2.7°	2.7°	9.0°	10.7°	11.3°

The danger of early blooming due to purple twigs may be avoided by whitewashing the twigs, thus giving them the desired color, or by getting new varieties of peaches, having more favorably colored twigs. Unfortunately the winter rains in most sections of the United States* wash off the whitewash spray that may be put on to protect the tree. The greater part of the country must therefore await the appearance of the new varieties.

We have at present many half wild seedling trees of the green color. They sometimes produce a fence corner crop under surprisingly adverse conditions, but those with marketable fruit have not yet appeared. To get them we will probably have to disown the results of European culture and go back to central or western Asia, the ancient home of the peach. There it has struggled with heat, not cold, and consequently these varieties may be better fitted to thrive in our continental climate, but it is yet to be learned whether or not Asia Minor, Persia or China have peaches of the quality that we require. While these facts are yet unknown Professor Whitten and others are trying to solve the problem at home by hybridization —mixing the strains of good peaches and hardy peaches so that the new variety may have the good qualities of both parents and the faults of neither. J. RUSSELL SMITH.

PHYTOGEOGRAPHY

Reforesting the Mountains of Southern California.—The disposition of the water which falls upon the surface of the earth is of the highest importance to all forms of life. Until recently man has not realized this, nor the fact that he can, to a certain extent, control the matter. "Run-off" is regulated by slope, amount of vegetation,

* The dry climate of the arid Southwest is more favorable for this method, practical experiments have produced profitable crops on whitened orchards when neighboring orchards bore no fruit.

nature of soil, violence of rainfall, rapidity of melting snows, time of year. The amount disposed of through evaporation and percolation depends directly or indirectly upon practically the same conditions. Vegetation is an important factor in each of the three processes.

To-day the Pacific slope of southern California is one of the garden-spots of the earth. It is a land of great richness. Here "every man may sit under his own vine and fig-tree." It is a centre of wealth, health and refinement. The mountains are the source of these blessings, for upon their peaks and slopes the rains and the snows are precipitated and from these reservoirs the water is fed to the valleys below.

Southern California is developing with marvelous strides, but unless its forests can be protected and its denuded mountain slopes reforested, this development cannot long continue. Great havoc has been wrought by immense bands of sheep. They not only trample up the grass and bushes, but they kill the young trees. Tremendous loss has resulted from fires also, due largely to the carelessness of camping parties and prospectors. Several times these fires have raged within sight of Pasadena.

The water, which in former times was held back by the vegetal covering and so distributed to the valleys throughout the year, now hurries down the slopes and is largely wasted. For instance, the basin of the San Gabriel with an area of 223 square miles discharged 100 miner's inches of water during the summer of 1900. The San Antonio, with a basin of about 25 square miles discharged 175 inches, while the precipitation in the two does not vary much. The San Gabriel basin has been visited by destructive fires while the San Antonio has not suffered seriously.

The government is beginning to realize our needs and is doing much toward the improvement of present conditions, through reforestation. This is under the supervision of Mr. T. P. Lukens, of Pasadena, a public-spirited man and one who fully understands the situation.

Mr. Lukens commenced planting seeds in 1898 but the succession of dry years which southern California has experienced, prevented many of them from germinating. This year the conditions have been very favorable and the work has been pushed with vigor. The field stretches from Santa Barbara to San Jacinto.

The *Pinus attenuata (tuberculata)* has been chosen, as it seems

best adapted to the existing conditions. There are about 20,000 seeds to the pound and a man can plant about 1,500 seeds per day.

Thirty forest rangers have been at work this season. Each man furnishes his own food and receives two dollars per day and in this way about 800 acres have been planted in patches varying from five to forty acres each. Generally the slopes facing the valley have been planted as the progress of the young trees can be most easily observed here. It is on these slopes that the trees will be of most benefit also.

A piece of gas-pipe three fourths of an inch in diameter and three and one half feet long is used to *cultivate* the ground. The pipe is sharpened at one end and bent at the other so as to form a handle. After loosening up the soil the pipe is pushed to one side and a seed dropped into the hole. Planting takes place every few feet. The north side of a stone or a bush is usually selected so that the seeds may get the full benefit of the moisture.

If this work proves to be successful, future generations will see the mountains of southern California clothed with magnificent forests, a source of joy to all beholders and a blessing to the dwellers in the land. J. F. C.

ECONOMIC GEOGRAPHY

Current Articles on Commerce and Industry.—Agriculture, Calendar for September, *Country Life*, Sept. (Ill.).

Agriculture, Calendar for October, *Country Life*, Oct. (Ill.).

Australia, Industrial Conditions, *Bradstreet's*, Sept. 27.

Anama Society, *The World To-Day*, Oct. (Ill.).

British Columbia, Mining Industries, *Engineering Mag.*, Oct.

Canada, Migration to, from the U. S., *Rev. of Revs.*, Sept. (Ill.).

Commerce and Technical Education, *The Mfgr.*, Oct. 1.

Corn, Breeding New Kinds of, *World's Work*, Sept. (Ill.).

Cotton, Culture of Sea Island, Textile Record, Sept. (Ill.).

Farmer's Balance Sheet for 1902, *Rev. of Revs.*, Sept.

Glucose, Its Uses and Adulterations, *Comm. Bull. and N. W. Trade*, Sept. 20.

Gypsum Industry, American, *Eng. and Mining Journ.*, Aug. 30. (Ill.).

Hawaii, What is the Matter with, *The World To-Day*, Oct. (Ill.).

Iron Industry, American, *Engineering Mag.*, Oct.

Irrigation Law and the West, *The World To-Day*, Oct. (Ill.).

Jamaican Negroes, *The World To-Day*, Oct. (Ill.).

Latin America, *World's Work*, Sept. (Ill.).

Manufacturers, The U. S. Census of, *Rev. of Revs.*, Sept.
Nebraska and the Census, *The Corn Belt*, Sept.
Nile Dam, *Harper's Weekly*, Sept. 6 (Ill.).
Nile Irrigation Works, *Scientific Am.*, Sept. 20 (Ill.).
Oyster Industry, *The World To-Day*, Oct. (Ill.).
Peach Growing, The Essentials of, *Country Life*, Sept. (Ill.).
Philippines, Trade Possibilities, *Monthly Summary of Commerce of Philippines*, Nov., 1901.
Philippines, Queer Craft in, *Scientific Am.*, Sept. 3 (Ill.).
Publishing Industry, *Mahin's Mag.*, Sept.
Russia's Rapid Progress, *The Mfgr.*, Oct. 1.
Silk, *Textile Record*, Sept.
Tin Plate Manufacture, *Scientific Am.*, Oct. 4 (Ill.).
Tobacco, Shade Grown, *Scientific Am.*, Sept. 6 (Ill.).
Town Making (Avalon, Santa Catalina) *Scientific Am.*, Sept. 27.
Turkey, Coal in, *Eng. and Mining Journ.*, Sept. 6.
Typewriter, the Rise of the, *The Mfg.*, Oct. 1.
Wireless Telegraphy, *The Mfgr.*, Sept. 1.

Wheat Growing on the Pacific Coast.—Wheat growing and the general agricultural conditions in the Pacific Coast region of the United States are made the subject of a recent bulletin of the Division of Statistics of the Department of Agriculture *(No. 20, Misc. Series, 1901)*. The broad, level fields of the grain country, especially in the great interior valley of the Sacramento and San Joaquin Rivers in California favor the use of agricultural machinery of the heaviest and most complex construction. Thus a combined harvester is used which makes it possible for three or four men to control the strength of 24 to 36 horses in cutting, thrashing, recleaning, and sacking the grain. All these operations are accomplished as quickly as the horses can pull the machine over the field. The differences in temperature between the northern and southern portions of the Pacific coast are not nearly so great as in the case of the Atlantic coast. There are, however, greater differences in the methods of conducting farming operations in different parts of the Pacific coast than throughout the entire length of the Atlantic seaboard. These differences are due to the extreme variations of rainfall. Oregon, Washington, and the northern portion of California have abundant rains throughout the entire crop-growing season. Mt. Shasta is practically the northern limit of the dry summer region which includes the larger portion of California. The rainfall decreases rapidly to the south, reaching

about four inches at the southern end of the San Joaquin valley. These small rainfalls (twenty inches and less) would be insufficient for cereals and most other crops unless the distribution of the rains throughout the year were favorable. As it happens, nearly all the rain usually falls within the period November to May, and by far the greater part comes in the three winter months. It is just at this time that a growing temperature for all the hardy crops prevails and the wheat crop makes its principal growth. Hence it is possible for grain and other crops to mature before the dry summer provided the limited amount of rainfall has been reasonably favorably distributed. Most of the common varieties of wheat raised in the Pacific Coast region belong to the Club Wheat group which is so named from the club-like formation of the head. These club wheats hold the grain well and are particularly suited to grow in a region of exceedingly dry summers where the grain after it is fully ripe is often left standing in the field for thirty to sixty days before it is harvested.

In the great valley of California the winter is the busy time for farmers for the grain must be put in between the rains. The wheat is sown from September to the middle of January, principally in November. The plant is usually mature before the heat of June can do it any harm. It is this very heat and dryness of the early summer which makes it possible to use the combined harvester and thresher, a machine which could not be successfully employed if the grain were not perfectly dry, as well as thoroughly ripe. Another great advantage of the rainless summers is the fact that the grain, after being sacked, can be left in the field, as it sometimes is for weeks, without fear of any material damage by the weather.

In Oregon heavy crops of wheat have been raised when not a drop of rain fell between seed time and harvest, and in Washington it is the general opinion that a rainfall of twelve inches a year is enough for raising a crop of wheat in the Palouse district. In this Palouse country there is an annual drought about two weeks before the harvest time, and much experimental work has been done with the object of obtaining a variety of seed that shall mature earlier. If such a variety could be secured, it is estimated that several million dollars a year would be added to the wealth of this region. On the larger farms in the flat valley bottoms of the Washington wheat district combined harvesters are used, but in most of the Palouse district self-binders are still employed, chiefly because the early rains make the grain too moist to be harvested with the combined machine.

R. DEC. W.

GEOGRAPHIC LITERATURE

BOOK REVIEWS

Elementary Physical Geography.—William Morris Davis. Boston, Ginn and Company, 1902. Pp. xviii + 401, with 19 plates and 190 figures. $1.25.

Davis's Elementary Physical Geography opens with a brief chapter on the Earth as a Globe; about one fifth of the text is devoted to a discussion of the Atmosphere; one twelfth to the Ocean; three elevenths to land forms; one ninth to Rivers and Valleys; one fourteenth is divided almost equally between Deserts and Glaciers; one thirteenth to Shore Lines; the remaining chapter, 40 pp., is given to Plants, Animals and Man.

The Elementary Physical Geography is a simplified and abbreviated form of Davis's Physical Geography; the final chapter has been added, and the chapter on the Atmosphere has been expanded for the elementary book.

All teachers of physical geography have experienced trouble in finding an order of subjects that answers equally well the scientific and the teaching aspects of the study. Possibly no one order can give universal acceptance; classes along the seashore and classes of the prairie regions would be expected to pursue different topics at some stages of the study. The teachers who write our physical geographies probably show in their books the influence of their teaching experience, therefore each writer may give us the order of subjects best suited to his own geographic environment.

On this theory the reviewer can account in part for the subject-order employed in some books; the theory, however, does not enable him to explain why a large fraction of the first half of a physical geography is devoted to the Atmosphere. While the demand of pure science may require an early knowledge of aerial controls, yet this demand is more than offset by the distressing effect on the scholar of seventy-five pages of temperature, winds, and attendant phenomena. For the average teacher this chapter is more difficult than any other division of the study; even when the laboratory is well equipped with weather instruments, the interest of the student is apt to lag before he succeeds in grasping the entire theory of atmospheric circulation. From the standpoint of the pupil we believe Professor Davis should have deferred his chapter on the atmosphere to the middle or latter part of the book.

Since so low a percentage of our schools are situated on or near the seashore, we feel that the treatment of the Ocean should follow at least a partial discussion of land forms.

Again, we would take exception to the order given "Rivers and Valleys." Every boy and girl has some acquaintance with river action; the observation may be limited to rivulets, possibly to mere wet weather streams; in any event our pupils know something of the influence which running water exercises on land surface. Hence the reason for suggesting that "Rivers" should have a position earlier in Professor Davis's book.

On page 14 we have a résumé of the nebular hypothesis; Professor Davis concludes this with the assertion, "it is not successful in explaining all features of the solar system"; we question the wisdom of this reservation.

With college classes the inability of this interesting hypothesis to account for every aspect of the solar system may be discussed with profit. If the theory is mentioned at all to the high-school student, let him enjoy it as a panacea; it gives him in space a platform on which he is proud of his ability to understand so much.

P. 77. "The tempered waters of the sea on the south and southeast." We do not find any authority that warrants this use of "tempered"; a few other words have been checked for their uncommon usage.

P. 100. We doubt whether the scholar will get a very clear idea from the comments on the relative compressibility of water and air. If he has aready studied physics this brief explanation may be sufficient.

P. 102. "Ice expands a little as it freezes; it therefore floats, about one seventh of its volume being out of water."

P. 104. "Icebergs, being of fresh water, float with about one sixth or one seventh of the volume above the sea surface." Here we have the whole truth so briefly put as to provoke in the scholar inquiry which will stimulate the teacher.

P. 109. Professor Davis gives a terse but lucid explanation of waves. Figure 42 "Orbital Movement of Water in Waves," illustrates wave movement, but no reference to the figure is made in the text; thus the two are not connected, so the illustration is quite useless to the student.

A very few technical terms when defined and first used in the book are italicized; the great percentage of such terms, however, appear in ordinary type; note especially the chapter on "The Lands." The first use of a technical term in a school text-book should be given the prominence of italics at least.

P. 157. An explanation of "The Fall Line" is broken into by figure 73 which has no direct connection with the subject under consideration. The space occupied by this figure should be given to fig. 79 of the Physical Geography, which does illustrate Fall Line.

In reading the book we note quite a few sentences that need recasting, *e. g.*, "The greater intelligence of many land animals than of sea animals should also be regarded as a result of the development of land animals amid a greater variety of geographical conditions than is found in the sea." Of all text-books those written for high-school use must be clear; every sentence should be read from the standpoint of the boy and girl who know nothing of the subject.

At the end of each of the first three chapters is a valuable supplement consisting principally of suggestions for observation work. A list of questions prepared by Mr. R. H. Cornish, of the Girl's High School, New York, accompanies each chapter. These questions will be very helpful to students.

The plates are few, but each has a marked teaching value; they were chosen with care, and the text makes use of them. A strong feature of the book is found in the diagrams of models representing ideal types of land forms. It is to be regretted, however, that the publishers have not made more plates in place of so many ordinary woodcuts.

Much to the advantage of both teacher and scholar there is given for each chapter an excellent bibliography for supplementary reading. To be used with the several chapters the Appendix also suggests lists of map sheets, "selected chiefly from those published by the U. S. Geological Survey, and the U. S. Coast and Geodetic Survey."

We are pleased to note that the connection between life, plant and animal, and physiographic features is not relegated to a chapter by itself. While Professor Davis gives the scholar a stimulating chapter on *The distribution of organic forms*, yet throughout the whole book he does not let slip an opportunity for fixing attention on the main side of Geography.

The book is not written on the theory that the boys and girls of our high schools require semi-kindergarten treatment for arousing interest; it is a strenuous book on a subject whose value is largely discipline. F. C.

The Physical Geography of the Texas Region.—The U. S. Geological Survey has published, in its topographic atlas series, a description of the physical features of the Texas region, by Robert T. Hill, which deserves a wide acquaintance in educational circles. The author, who has had unusual opportunities for travel in Texas and the adjoining regions of Indian Territory and New Mexico, summarizes the important features of this interesting country in a descriptive review, which, without being unduly burdened with technicalities, is still scientifically accurate.

The Texas region is of particular physiographic interest and importance, both from its unusual size and from its location in the southern and narrowing portion of the continent where the great topographic features of the country more or less converge. Thus it is that in Texas are found portions of several of these larger topographic divisions, for example the Coastal Plain is represented in the lowlands extending along the Gulf of Mexico; the Appalachian Uplift appears in the Ouachita Mountains; the Great Plains reappear in the Llano Estacado and the Edwards and Stockton plateaus, and the Cordilleran mountain system is represented in the mountains of the extreme western part of the region. All the mountain ranges, plains and plateaux are described at length, as are also the drainage features which, besides being of great economic importance to the state, are quite diverse in their origin and features. Nowhere is there a more intimate relation between geologic formation and physiography than in the Texas region. Each formation in the state has peculiarities of stratification, consolidation and friability, which, when the formation is acted upon by the climate, result in a variety of relief forms. Particular attention in the folio is called to the topography resulting from the great variety of the geologic structure. The folio also includes a discussion of the climatic features, in which there are great extremes, the vegetation, economic features, mineral resources and the distribution of the population. Numerous maps, charts and half-tone views illustrate in a striking and interesting manner the topography and other features of this remarkable country, and a large double-page map, compiled from various sources, which is by far the best map of the region extant, accompanies the folio.

G. B. H.

The Desert.—John C. Van Dyke. 7 x 5 in. New York, Charles Scribner's Sons. 1901. Pp. 233, full page photogravure frontispiece. Price, $1.25 net.

We usually think of the desert as a most uninteresting place, utterly abandoned by all living things, and I fear, it is usually thought of as a "sea of sand." But the real desert, with its mountain ridges, its flood swept canyons and its sheet flood plains, its scant but aggressive population in plant

and animal life, is an undiscovered country to nearly all the world. A Gerome or a Bridgman comes back from the desert with canvasses showing a wealth of mysterious color in sky and desolate expanse, and the crowd admires the canvas, and thanks the artist for supplying the color. Or a Kipling or a Baker comes out of the great solitude and writes a luminous page or so, which burns into our memory the picture of the tawny sands and the pitiless copper sky. But now comes a man, who is artist and poet, and who sees with the eye of science and understands, and revels in the wide and wonderful beauty of the desert, and generously shares his pleasure with all the world.

In "The Desert," we have concrete specific geography, resting, as it should, on a logical basis of science, and with all the warmth and beauty of very fine literature. The region described lies about the head of the Gulf of California. The sky, with its marvelous color, the drifting sand and blistering rocks, the Colorado now become the "Silent River," the bitter struggle for existence by plant and animal, and their splendid adaptations to the hard conditions, the illusions of the desert, then the foothills and the western mountain barrier,—each topic is treated with a vividness that makes it read like romance.

It seems almost like cavilling to find fault with the book, yet there are some errors that need to be challenged. In the atmospheric circulation of the Yuma region, the overflow to the west is almost nil. In the northern summer, this region becomes essentially a fixed cyclonic center, and the uplifted central air is known to overflow almost wholly to the eastward. So Dr. Van Dyke may be relieved of his anxiety (page 58) about any effect, evil or otherwise, which the irrigation of the flat lands near the mouth of the Colorado River may have on the climate of Southern California.

Again, the author's explanation of the mirage, page 118, as due to a lens-like action of the atmosphere, is gratuitous, and wholly untenable. Looming, as stated, is due to refraction through denser air, but all cases of inverted image, whether below the horizon, as in a pool, or hanging in the sky above the object, are easily demonstrated as due to reflection from air surfaces on layers of air of widely different density. J. P. G.